Journal Pre-proof

Prevalence of SARS-CoV-2 infection and SARS-CoV-2-specific antibody detection among health care workers and hospital staff of a university hospital in Colombia

Nohemí Caballero MD , María A. Nieto MD ,
David A. Suarez-Zamora MPH , Sergio Moreno MSc ,
Camila I. Remolina MD , Daniela Duran MD , Daniela Vega MD ,
Paula A. Rodríguez-Urrego MD , Claudia P. Gómez MPs ,
Diana P. Rojas PhD , Andrea Ramírez PhD , Oscar Martínez MD ,
Ana M. Baldión-Elorza MD , Luis J. Hernández PhD ,
Juliana Quintero PhD(c)

PII: S2772-7076(22)00042-X
DOI: https://doi.org/10.1016/j.ijregi.2022.03.013
Reference: IJREGI 88

To appear in: *IJID Regions*

Received date: 16 February 2022
Revised date: 16 March 2022
Accepted date: 17 March 2022

Please cite this article as: Nohemí Caballero MD , María A. Nieto MD , David A. Suarez-Zamora MPH , Sergio Moreno MSc , Camila I. Remolina MD , Daniela Duran MD , Daniela Vega MD , Paula A. Rodríguez-Urrego MD , Claudia P. Gómez MPs , Diana P. Rojas PhD , Andrea Ramírez PhD , Oscar Martínez MD , Ana M. Baldión-Elorza MD , Luis J. Hernández PhD , Juliana Quintero PhD(c) , Prevalence of SARS-CoV-2 infection and SARS-CoV-2-specific antibody detection among health care workers and hospital staff of a university hospital in Colombia, *IJID Regions* (2022), doi: https://doi.org/10.1016/j.ijregi.2022.03.013

Highlights

- Prevalence of SARS-CoV-2 infection on hospital workers was low.
- The presence of antibodies against the virus was high in healthcare workers.
- Some professions had a higher chance of being SARS-CoV-2 seropositive.

Pre[illegible]re workers and hospital staff of a university hospital in Colombia.

Nohemí Caballero, MD[1,2]; María A. Nieto, MD[1,2]; David A. Suarez-Zamora, MPH[1]; Sergio Moreno, MSc[2] ; Camila I. Remolina, MD[1,2]; Daniela Duran, MD[1,2]; Daniela Vega, MD[1,2]; Paula A. Rodríguez-Urrego, MD[3]; Claudia P. Gómez, MPs[1]; Diana P. Rojas PhD; Andrea Ramírez, PhD[2]; Oscar Martínez, MD[3]; Ana M. Baldión-Elorza, MD[3]; Luis J. Hernández, PhD[2]; Juliana Quintero, PhD(c)[1,4].

1. Division of Population Health, Fundación Santa Fe de Bogotá, Colombia.

2. School of Medicine, Universidad de los Andes, Colombia.

3. Department of Pathology and Laboratories, Fundación Santa Fe de Bogotá, Colombia.

4. Department of Internal Medicine, Fundación Santa Fe de Bogotá, Colombia.

Correspondence author: Juliana Quintero, Division of Population Health, Fundación Santa Fe de Bogotá, Cra 7b #123-90, 110111, Colombia. E-mail: juliana.quintero@fsfb.org.co, Phone: (+571) 6030303 ext. 5715

Abstract

Obj [illegible] k factors associated with seropositivity among HCWs between June and October of 2020.

Methodology: We analyzed data from the day of enrollment of a prospective cohort study, to determine point prevalence and seroprevalence of SARS-CoV-2 infection in HCWs of a university hospital in Colombia. We collected respiratory samples to perform RT-PCR tests and blood samples to measure SARS-CoV-2 IgM and IgG antibodies. We collected and analyzed data on nosocomial and community risk factors for infection.

Findings: 420 hospital staff members were included. The seroprevalence at baseline was 23·2%. Of which 10·7% had only IgM, 0·7% had IgG, and 11·7% had IgM and IgG antibodies. The prevalence of acute SARS-CoV-2 infection was 1·9%. Being a nurse assistant was significantly associated with seropositivity compared with all other job duties (PR 2·39, 95%CI: 1·27 - 3·65, p=0,01).

Conclusions: Overall SARS-CoV-2 prevalence was 1·9% and seroprevalence was 23·15%. Nurse assistants, medical doctors or students, and laboratory workers had a higher possibility of being SARS-CoV-2 seropositive.

Keywords: COVID-19, SARS-CoV-2, COVID-19 Serological Testing, Health Personnel, Seroepidemiologic Studies.

Journal Pre-proof

Introduction

The Coronavirus Disease 2019 (COVID-19) pandemic started as a cluster of pneumonia cases in Wuhan, China, in December 2019 (Salata et al., 2019). A few weeks later, the Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2), the virus that causes COVID-19, was identified, and China shared the genetic sequence on January 12th, 2020 (WHO, n.d.). In March 2020, the World Health Organization (WHO) declared a global pandemic, and a year later, there were more than 147 million cases reported and more than 3 million deaths due to COVID-19 across the world (Google-News, n.d.). In Colombia, the first COVID-19 case was reported in March 2020. Since then, three waves have occurred (Vista de COVID-19 en [illegible]). Until July 24th, 2021, 24,186 accumulated cases of confirmed COVID-19 in healthcare workers (HCWs) have been reported in Bogotá, corresponding to 1·7% of all COVID-19 cases in the city (COVID-19 Trabajadores salud | SALUDATA, n.d.).

Evidence supports that HCWs have a higher risk of infection by SARS-CoV-2 due to their direct contact with patients (Grant et al., 2021). They also might have a higher risk of severe infection, as it is presumed that the risk of mortality is higher on those who acquired the infection through nosocomial transmission than those with community transmission (Wang et al., 2020). Multiple risk factors have been associated with COVID-19 infection in HCWs, including lack of personal protective equipment, workplace setting, profession, and increased exposure to the virus (Gholami et al., 2021). Epidemiological surveillance is fundamental to monitor the pandemic and formulate immediate and long-term strategies to mitigate its burden. The screening of asymptomatic HCWs allows early detection of infection and aims to reduce the rate of transmission to patients and colleagues. Thus, this study aimed to determine recent and previous SARS-COV-2 infection and describe the risk factors associated with SARS-CoV-2 infection among active workers of a University Hospital in Bogotá, Colombia, during the COVID-19 pandemic between June and October of 2020. This time frame included part of the first wave of the SARS-CoV-2 in the country, which occurred between July and August of 2020 (Figure 1).

Methods

Study setting

We conducted this study in a University Hospital that provides high complexity, timely, and top-quality certified services to patients in Bogotá, Colombia, with over 3,000 employees. The Hospital has specific COVID-19 emergency room, hospitalization, and intensive care unit (ICU) beds and is a referral hospital in the city for COVID-19 medical attention. Bogotá is the capital of Colombia, and has a population of 7.834.167 inhabitants. The city is divided into 20 localities, one of them is Usaquén, where the University Hospital is located, and the first case of COVID-19 in Colombia was detected.

Study design

We conducted a prospective cohort study, as part of the CoVIDA project (Ruiz-Gómez and Carrasquilla-Barrera, 2021), an initiative for active epidemiological surveillance in Bogotá, Colombia (Amendola et al., 2020; Varela et al., 2021). In this study, we proposed a testing scheme for respiratory and blood sampling according to the RT-PCR results of participants at baseline. (See supplementary material 2)

All active workers regardless of their risk of SARS-CoV-2 exposure were invited to voluntarily participate, via institutional e-mail, in a 6-month study to assess the impact of SARS-CoV-2 infection in the hospital. Here we analyzed only data from the day of enrollment of each participant to determine point prevalence and seroprevalence of SARS-CoV-2 infection. Individuals who desired to participate and met the eligibility criteria were assigned an appointment to join the study. The inclusion criteria included: 1) women and men older than 18 years and 2) active hospital workers. We excluded participants with contraindications for collecting nasopharyngeal and blood samples.

We recruited participants between June 25th and October 30th of 2020 (Figure 1). On the first visit, we obtained informed consent, performed a medical evaluation, and recorded weight, height, and vital signs from all participants. Then, we applied a risk factor questionnaire for nosocomial and community SARS-CoV-2 transmission created based on the recommended standard approach according to the “Survey tool and guidance Rapid, simple, flexible behavioral insights on COVID-19” of the World Health Organization (World Health Organization, 2020). Lastly, we collected a respiratory sample via nasopharyngeal swaps to perform RT-PCR for SARS-CoV-2 and a blood sample by phlebotomy to measure SARS-CoV-2 IgM and IgG antibodies. Blood samples were stored and processed at the department of pathology and laboratory medicine of the University Hospital, while respiratory samples were transported and analyzed at GenCore Laboratory of Universidad de los Andes.

Molecular and serological tests

RT-PCR molecular test was performed to detect SARS-CoV-2 infection using the U-TOP™ COVID-19 Detection Kit, according to the manufacturer's instructions. This kit detects: Gen N, gen ORF1ab, Rnasa P, IPC [illegible] of 100·0% [95% CI: 86·68% - 100·00%](SEASUN BIOMATERIALS, 2021).

To measure SARS-CoV-2 IgM and IgG antibodies, we used different serological kits based on immunochromatography, depending on their availability in our laboratory. One of the kits employed was HighTop SARS-CoV-2 IgM/IgG Antibody Rapid Test (HIGHTOP Biotech), which is an immunochromatographic assay, using a capture method for the qualitative detection of SARS-CoV-2 IgM/IgG antibody in human serum. One full drop of serum (10 µL) was added into the sample well, then two drops (80-100 µL) of sample buffer were added. The test results were observed within 15 - 20 minutes (no longer than 20 minutes since abnormal results may occur). This kit reports a 94·15% sensitivity and 93·91% specificity for IgG and IgM. The second kit employed was the 2019-nCOV IgG/IgM Rapid Test (Dynamiker Biotechnology (Tianjin) Co., Ltd.), an immunochromatographic assay for the detection of SARS-CoV-2 IgG and IgM antibody in human whole blood/serum/plasma. A 10 µL of serum sample was added to the sample pad, then 60 µL of dissolution solution was added. The results were read after 10 minutes. This kit reports a 93·20% sensitivity and 95·30% specificity for IgG and IgM.

Data collection

We obtained clinical data from the hospital's electronic medical records, including comorbidities, chronic medications use, flu vaccination, and previous viral infections. Meanwhile, we extracted the following data from COVID-19 risk factors questionnaire: demographic characteristics (such as age, sex, socioeconomic status, and household's location), hospital ward, type of job, aerosol exposure, community exposure (type of transportation used, rooms at home), and adherence to preventive strategies (such as frequency and duration of handwashing and use of masks). In addition, through medical records, we collected data on possible confounders such as working in more than one hospital ward and handwashing frequency and duration. We also measured vital signs and anthropometric measures. Cardiac frequency and Oxygen saturation were measured using a pulse oximeter. Respiratory frequency was measured by counting the number of participants' breaths in a minute, while in a sitting position. Blood pressure was measured using a digital mo[illegible]nt with a meter fixed on the wall.

Statistical Analysis

We summarize baseline socio-demographic characteristics. Categorical data are presented as frequencies and percentages and quantitative variables are presented as means, medians, IQR, and standard deviations. Seroprevalence (seropositive for IgM and/or IgG against SARS-CoV-2) data and COVID-19 prevalence (detection of SARS-CoV-2 using RT-PCR) are expressed as proportions. Categorical variables were compared using Pearson's chi-squared test, and ordinal variables were compared using the U-Mann Whitney and Kruskal-Wallis tests. All P-values were two-sided and $P<0{\cdot}05$ was considered to indicate significance.

We categorized the level of exposure to SARS-CoV-2 according to the hospital ward, participation in aerosol-generating procedures, and type of occupation (Table 1). Type of occupation was categorized as healthcare, blended and administrative. Healthcare workers were all those who deliver care to patients directly (e.g., doctors and nurses) or indirectly (e.g., Laboratory technicians). Blended workers were those who performed both administrative and patient-related tasks.

Bivariate and multivariate penalized logistic regression analyses were used to assess factors associated with seroprevalence of SARS-CoV-2, as well as for adjusting for confounders and detecting effect modification variables. Regression models were conducted using seropositivity status as the dependent variable, and all plausible independent variables (age, sex, previous COVID-19, socioeconomic stratification, type of occupation, profession, working in more than one hospital ward, aerosol exposure, handwashing frequency and duration, and number of cohabitants in the household). A reduced model with the minimum number of variables that best suits the data was performed. The best reduced regression model was selected based on Akaike's information criterion. Due to the high prevalence of seropositivity (>10%), we used the prevalence ratio as the association measure, as Odds ratios, in this case, may overestimate the association. We tested penalized logistic regression model assumptions. Observations are independent as each came from an individual participant, without repetition. We confirmed no multicollinearity using Variance Inflation Factor

(VI er dropping these observations. Resulting in 393 observations for the multivariate model and 395 observations for the multivariate reduced model. We tested linearity using the linktest for the multivariate and reduced model and confirmed the assumption. Missing data corresponds to 4.78% of the sample size, we decided to drop it as it is less than 5%. Systematic biases were reduced by obtaining data with digital devices previously calibrated. Questionnaires and medical records were conducted by trained personnel, reducing the interviewer bias. Analysis was performed in Stata SE 17.0.

Ethics

The study protocol was approved in June 2020 by both ethics committees, Fundación Santa Fe de Bogotá and Universidad de los Andes (Approval No. 1181). All participants provided written, informed consent before enrolment in the study. The study adheres to the international regulations stated in the Helsinki Declaration of 1975, Nuremberg's Code, and Belmont inform.

Role of the funding source

This study received funding from Fundación Santa Fe de Bogotá to conduct research activities including recruitment of study subjects, collection of nasopharyngeal samples, and collection and processing blood samples and from Universidad de los Andes to transport and process respiratory samples to perform RT-PCR.

Results

In total 584 hospital workers were invited to participate in the study, 424 of them agreed to participate and met the eligibility criteria, 420 of them attended the enrollment tests and were included in the analysis. During the study recruitment period (from June 25th to October 30th, 2020), 982,552 new cases of COVID-19 were reported in Colombia, 30·0% (294,270) of them from Bogotá. The mean age of participants was 39·7 years (with a standard deviation of 9·8), and 75·7% were females. The majority (35·5%) of participants were nurses, followed by medical doctors (18·3%), both of whom primarily held healthcare positions. At least 30% presented a comorbidity (Table 2).

The ... d IgG only, and 11·7% had both IgM and IgG antibodies. The prevalence of acute SARS-CoV-2 infection, determined by a positive RT-PCR test result at baseline, was 1·9% (n=8). About 7·4% (n=31) of participants had a confirmed COVID-19 diagnosis before recruitment. Baseline tests were performed between June 25th and October 30th, 2020, and a higher proportion of positive tests was detected in early October (Figure 1, Supplementary material).

When comparing sociodemographic and clinical characteristics of participants by serostatus, most seropositive individuals were younger than 50 years (82·9%), with no significant differences between age groups. More than half (63·9%) of the seropositive participants performed healthcare activities and belonged to a mid-socioeconomic status (62·8%). Up to 30% of all HCWs reported at least one comorbidity, and there were no significant differences in comorbidities by serostatus (Table 2). Among all participants, 27·9% presented at least one symptom, but there were no significant differences in the reporting of COVID-19-related symptoms among seropositive and seronegative individuals (Table 2). The most reported symptoms were sore throat (12·2%), cough (5·3%), and fatigue (3·1%).

Among PCR positive participants, 75% (n=5) presented at least one COVID-19 related symptom. Common symptoms reported by them were sore throat (25%), cough (25%), fever (12·5%) and fatigue (12·5%). 87·5% of PCR positive participants at baseline, worked in only one hospital ward. 62·5% had a healthcare occupation and 75% reported to wash their hands more than 10 times in a work shift. Regarding community transmission factors, 50% of PCR positive participants lived in a high socioeconomic stratum and 50% lived with 0 to 1 person.

The overall seroprevalence was similar in all levels of risk exposure by work area (22·6% in high risk, 26·8% in intermediate-risk, and 18·9% in low risk). Most seropositive individuals had only IgM or both IgM and IgG antibodies. The prevalence of only IgG antibodies was insignificant, comparable among participants in the high and intermediate exposure wards (0·9% and 0·8%, respectively). No participants in the low-exposure wards had IgG antibodies (Figure 2. C). Individuals not exposed to aerosol-generating procedures had a higher seroprevalence compared to those who performed aerosol procedures (23·71% vs.

23· [illegible] p exposed to aerosols compared to the non-exposed group (11·59% vs. 10·82%) (Figure 2. B). The proportion of seropositive participants was higher in healthcare (23·9%) and administrative workers (28·9%), followed by blended workers (13·5%). The prevalence of IgG antibodies was higher on administrative and HCWs (1·11% and 0·77%, respectively) (Figure 2. A). However, none of the differences between groups was statistically significant.

Table 3 presents the results from the multivariate regression_model. The proportion of seropositive participants is 4.84-fold greater if a person reported previous COVID-19, compared to those without previous infection (95% CI: 3·89 -5·22). SARS CoV-2 seroprevalence was higher in females (PR 1·4, 95% CI: 0·79-2·25), however, there was no significant association between sex and seropositivity. Participants from a high socioeconomic stratum are less likely to be seropositive than a low socioeconomic stratum, but there is no significant association between socioeconomic stratum and seroprevalence (PR 0·79, 95% CI: 0·44-1·36). Healthcare and blended occupations were less likely to be seropositive compared with administrative occupations (PR 0.44, 95%CI:0·17-1·07) but these results have no statistical significance. The proportion of seropositive participants was higher in nursing assistants, medical doctors and medical students and laboratory workers compared to professional nurses (PR 2·21 p= 0·032, 2·18 p= 0·039 and 2·21 p= 0·049, respectively). There are no statistically significant differences in seroprevalence between participants exposed and non-exposed to aerosol-generating procedures (PR 1·63, 95% CI: 0·91-2·60). Those who worked in more than one ward are less likely to be seropositive (PR 0·80, 95% CI: 0·38 – 1·54). Finally, people living with 4 cohabitants or more, are more likely to be seropositive (PR 1·28, 95% CI: 0·63- 2·27), compared to those who lived with 0 to 1 cohabitant.

The reduced model **(**Table 3**)** included the following independent variables: previous COVID-19, type of occupation, and profession. The model evidenced that healthcare professionals were less likely to be seropositive compared to administrative professionals (PR 0·45, 95% CI: 0·18-1·03), but this association remained without statistical significance. Being nursing assistants significantly associated with a higher seroprevalence in comparison with professional nurses (PR 2·39, 95%CI: 1·26-3·65), while medical doctors and [illegible] re likely to be seropositive than professional nurses (PR 1·7, 95% CI: 0·89-2·80 and PR 2·02 0·98- 3·34, respectively).

Discussion

To our knowledge, this is the first study in Colombia to estimate the seroprevalence of SARS-CoV-2 and the prevalence of SARS-CoV-2 infection in hospital staff, including healthcare and administrative workers (SeroTracker, n.d.). We found that the point prevalence of SARS-CoV-2 nasopharyngeal carriage was 1.9%, with an overall seroprevalence estimate of 23.15%, which was similar to the one reported among healthcare workers in Bogotá measured between October 26 and November 17, 2020, by the National Institute of Health (INS) (30%; 95% CI: 0.26-0.34) (Estudio Nacional: Seroprevalencia, n.d.). However, we conducted our study at a different time during the COVID-19 pandemic. The seroprevalence reported among healthcare workers by the INS was higher than the estimated for the general population in the city at the same time (26%)(Estudio Nacional: Seroprevalencia, n.d.). The enrollment period of the study coincided with the first COVID-19 wave (Supplementary Material, Figure 1), and sectoral quarantines were one of the different public health measures taken to reduce disease transmission. As a result, between June and October 2020, intensive care unit (ICU) occupancy fluctuated between 60% and 97% (Secretaría de Salud Bogotá, 2021).

Journal Pre-proof

The data from this study is part of an epidemiologic surveillance initiative of Universidad de Los Andes to assess SARS-CoV-2 carriage in high-risk professions. Hospital workers had the lowest SARS-CoV-2 infection rates among all professions screened (2.49%). However, military personnel and security guards had the highest rates of SARS-CoV-2 infection (18.86% and 6.02%, respectively) (COVID-19 Vacunómetro | SALUDATA, n.d.), which could be explained by a better understanding and higher adherence to measures to reduce infection risk among hospital workers (Abeya et al., 2021; Colmenares-Mejía et al., 2021).

A similar study performed on healthcare workers and medical students between June 25 and July 4, 2020, in another hospital in Bogotá reported an IgG seroprevalence rate of 2.28% measured by chemiluminescent immunoassay (CLIA) (Ariza et al., 2021). Estimate higher than our IgM-/IgG+ seroprevalence (0.72%) but low n may explain this distinction. Their study used both qualitative and quantitative methods for IgM (ELFA and LFA) and IgG (CLIA and LFA) detection. In contrast, we used a qualitative method (immunochromatography). These techniques have different diagnostic performances (Ariza et al., 2021). A meta-analysis on factors related to seroprevalence in healthcare workers showed that increased sensitivity of antibody tests was associated with increased seroprevalence (Galanis et al., 2021). Other reported factors associated with seropositivity included male gender, ethnicity, working in COVID-19 units, patient-related work, frontline healthcare workers (HCWs), healthcare assistants, shortage of personal protective equipment, previous positive RT-PCR test, and household contact with a suspected or confirmed COVID-19 case (Galanis et al., 2021).

The overall seroprevalence of SARS-CoV-2 in the Bucaramanga Metropolitan Area reported during the last trimester of 2020 was 19.5% (95% CI: 18.6–20.4), with a similar prevalence in healthcare workers. Our study reported a higher prevalence which could be explained by the different contexts of the cities, being Bogotá the capital of the country with a higher population density. In addition, a cross-sectional study that assessed the prevalence of SARS-CoV-2 on healthcare workers in ten cities of Colombia, from September to November 2020, reported a seroprevalence of 35% (95% CI: 33.0%-37.0%) (Colmenares-Mejía et al., 2021). The seroprevalence estimated for healthcare workers in Bogotá was 34%. One of the highlights of this study was that small cities (less than 1.5 million inhabitants) presented a higher seroprevalence compared to big ones (Malagón-Rojas et al., n.d.).

We demonstrate that nursing assistants in our hospital were at higher risk of having SARS-CoV-2 antibodies than professional nurses (PR: 2.39; 95% CI: 1.27-3.65). A similar study on healthcare workers at Oxford University Hospitals in the United Kingdom showed that most seropositive workers were nurses and health care assistants (47.2%) (Lumley et al., 2021). We also found that laboratory workers were 2.02 times more likely to be seropositive (95% CI: 0.98-3.34), which is interesting as previous studies have stated a low seroprevalence in this group (Amendola et al., 2020; Fukuda et al., 123AD; Milazzo et al., 2021). Although

this f-
perceived risk of infection and adherence to preventive measures.

Other studies have demonstrated an association between poor adherence to hand washing and the use of personal protective equipment (PPE) and COVID-19. A systematic review of the literature found that unqualified handwashing (OR: 2.64, 95% CI: 1.04-6.71), suboptimal hand hygiene before patient contact (OR: 3.10, 95% CI: 1.43-6.73), and inadequate use of PPE (OR: 2.82, 95% CI: 1.11-7.18) were risk factors for SARS-CoV-2 infection (Gómez-ochoa et al., 2020). However, we did not find this association, which could be explained by our hospital's high adherence to these practices. Our results support that SARS-CoV-2 infection can be an occupational disease, affecting more healthcare professionals than other hospital workers in specific scenarios (Carlsten et al., 2021; Sandal and Yildiz, 2021). Our results could be used to enhance biosafety protocols to reduce SARS-CoV-2 transmission in hospital environments.

Our study has some limitations. It only reflects the seroprevalence in healthcare workers in four months, and these results may vary across time according to the dynamics of the COVID-19 pandemic in Bogotá. Participants self-presented to enroll, which may introduce selection bias in the study cohort. Additionally, qualitative serology tests can add measurement bias due to interobserver variability. We used two different serology kits with similar performance according to their availability in the laboratory. Finally, obsequiousness bias may be present because participants self-reported hand hygiene practices and the type and duration of wearing face coverings. Sample selection was non-probabilistic through consecutive sampling.

We consider it crucial to monitor the seroprevalence in healthcare workers, especially in the context of COVID-19 vaccination, as we can now assess both previous COVID-19 infection and antibody presence due to COVID-19 vaccination. Studies on the immunogenicity of vaccines in healthcare workers have shown that women, non-obese and young people have a superior humoral immune response (Lustig et al., 2021). In addition, people with previous COVID-19 infection who received one dose of an mRNA vaccine have a similar humoral and cellular response to those without previous infection and received two doses of the vac[illegible]ne duration of natural and artificially induced immune responses need to be performed.

As we mentioned, this study is part of a prospective cohort study. We have already completed follow-up period, and we are currently analyzing the data to report findings of incidence, seroconversion, and factors of SARS-CoV-2 infection. Additionally, we are assessing the natural, artificial, and hybrid humoral immune response against SARS-CoV-2 in participants infected and/or vaccinated against COVID-19 during the study's follow-up period.

Conclusions

In conclusion, the overall SARS-CoV-2 prevalence of healthcare workers and hospital staff at a university hospital in Colombia was 1.9%, and the seroprevalence was 23.15%. Being a nurse assistant, medical doctor, or student and laboratory personnel was associated with a higher chance of having antibodies against SARS-CoV-2.

Contributors

Nohemi Caballero Prada (Investigation, methodology, data curation, formal analysis, visualization, writing-original draft, writing – review & editing); María A. Nieto Rojas (Investigation, methodology, data curation, formal analysis, visualization, writing-original draft, writing – review & editing); David Suarez- Zamora (supervision, formal analysis, and writing–review & editing); Sergio Moreno Lopez (Formal analysis, methodology, writing-review & editing); Camila Remolina Bermeo (Methodology, data curation, investigation, writing - review & editing); Daniela Duran Moreno (Investigation, data curation, writing-review & editing); Daniela Vega Hoyos (Methodology, investigation, data curation, Writing – review & editing); Paula Rodriguez-Urrego (Resources, supervision, writing - review & editing); Claudia P. Gómez Lopez (Project administration, supervision, investigation, Writing – review & editing); Diana Rojas Alvarez (Conceptualization, methodology, writing - review & editing); Andrea Ramírez Varela (Supervision, methodology, resources, writing - review & editing); Oscar Martínez-Nieto (Methodology, writing - review & editing); Ana M. Baldion-Elorza (Methodology, writing - review & editing); Luis J. Hernández

(M… g acquisition, resources, investigation, study administration, supervision, writing-review and editing).

Acknowledgments

We will like to express our great appreciation to all health workers that participated in our study, We will also like to acknowledge the various people and institutions for their contribution to this study: Dr. Henry Gallardo, director of Fundación Santa Fe de Bogotá, for supporting the conduction and funding of the study. Dr. Dario Londoño, director of the Population Health division at Fundación Santa Fe de Bogotá for supporting the conduction and funding of the study Ángela Ortiz, Drs Lilian Peñuela and Jose de la Hoz from the Division of Clinical Research at Fundación Santa Fe de Bogotá, for the initial support in participant inclusion and study procedures, Yubelly Malaver, Dallana Melo and all technicians (Department of pathology and laboratory medicine of Fundación Santa Fe de Bogotá) for the assistance in all laboratory procedures (sample collection, sample processing, and data curation), Pilar Castro and Leonardo Valdez (Division of Population Health) and CoVIDA team (Universidad de los Andes) for logistic support.

Declaration of interests

The authors declare no conflicts of interest.

Data sharing

Data collected from the study, including individual participant data that underlie the results reported in this article (after de-identification), data dictionary, and other related study documents (protocol, questionnaires) will be available upon reasonable request to the corresponding author.

REFERENCES

Abeya SG, Barkesa SB, Sadi CG, Gemeda DD, Muleta FY, Tolera AF, et al. Adherence to COVID-19 preventive measures and associated factors in Oromia regional state of Ethiopia. PLoS One 2021;16:e0257373. https://doi.org/10.1371/JOURNAL.PONE.0257373.

Amendola A, Tanzi E, Folgori L, Barcellini L, Bianchi S, Gori M, et al. Low seroprevalence of SARS-CoV-2 infection among healthcare workers of the largest children hospital in Milan during the pandemic wave. Infect Control Hosp Epidemiol 2020a. https://doi.org/10.1017/ice.2020.401.

Angyal A, Longet S, Moore S, Payne RP, Harding A, Tipton T, et al. T-Cell and Antibody Responses to First BNT162b2 Vaccine Dose in Previously SARS-CoV-2-Infected and Infection-Naive UK Healthcare Workers: A Multicentre, Prospective, Observational Cohort Study. SSRN Electron J 2021. https://doi.org/10.2139/ssrn.3812375.

Ari seroconversion rates to SARS-CoV-2 in interns, residents, and medical doctors in a University Hospital in Bogotá, Colombia. Infectio 2021;25:145–52. https://doi.org/10.22354/IN.V25I3.938.

Carlsten C, Gulati M, Hines S, Rose C, Scott K, Tarlo SM, et al. COVID-19 as an occupational disease. Am J Ind Med 2021;64:227–37. https://doi.org/10.1002/ajim.23222.

Colmenares-Mejía CC, Serrano-Díaz N, Quintero-Lesmes DC, Meneses L, Acosta IS, Idrovo ÁJ, et al. Seroprevalence of sars-cov-2 infection among occupational groups from the bucaramanga metropolitan area, Colombia. Int J Environ Res Public Health 2021;18:4172. https://doi.org/10.3390/IJERPH18084172/S1.

COVID-19 Trabajadores salud | SALUDATA. n.d. https://saludata.saludcapital.gov.co/osb/index.php/datos-de-salud/salud-laboral/covid-19-trabajadores-salud/ (accessed May 24, 2021).

COVID-19 Vacunómetro | SALUDATA. n.d. https://saludata.saludcapital.gov.co/osb/index.php/datos-de-salud/enfermedades-trasmisibles/covid-19-vacunometro/ (accessed June 15, 2021).

Ebinger JE, Fert-Bober J, Printsev I, Wu M, Sun N, Figueiredo JC, et al. Prior COVID-19 Infection and Antibody Response to Single Versus Double Dose mRNA SARS-CoV-2 Vaccination 2021 https://doi.org/10.1101/2021.02.23.21252230.

Instituto Nacional de Salud, Estudio Nacional: Seroprevalencia. n.d. https://www.ins.gov.co/estudio-nacional-de-seroprevalencia/reporte.html#curso (accessed June 23, 2021).

Fukuda H, Seyama K, Ito K, Ai T, Nojiri S

Galanis P, Vraka I, Fragkou D, Bilali A, Kaitelidou D. Seroprevalence of SARS-CoV-2 antibodies and associated factors in healthcare workers: a systematic review and meta-analysis. J Hosp Infect 2021;108:120–34. https://doi.org/10.1016/J.JH, Hori S, et al. SARS-CoV-2 seroprevalence in healthcare workers at a frontline hospital in Tokyo. Sci Reports | 123AD;11:8380. https://doi.org/10.1038/s41598-021-87688-9.IN.2020.11.008.

Gholami M, Fawad I, Shadan S, Rowaiee R. COVID-19 and healthcare workers: A systematic review and meta-analysis | Elsevier Enhanced Reader. Int J Infect Dis 2021.

Gómez-ochoa SA, Franco OH, Rojas LZ, Raguindin PF, Roa-díaz ZM, Wyssmann BM, et al. Systematic Review and Meta- and Pooled Analysis COVID-19 in Health-Care Workers : A Living Systematic Review and Meta-Analysis of Prevalence , Risk Factors , Clinical Characteristics , and 2020;00:1–15. https://doi.org/10.1093/aje/kwaa191.

Google-News. Coronavirus (COVID-19) n.d. https://news.google.com/covid19/map?hl=es-419&gl=US&ceid=US%3Aes-419 (accessed May 19, 2021).

Grant JJ, Wilmore SMS, McCann NS, Donnelly O, Lai RWL, Kinsella MJ, et al. Seroprevalence of SARS-CoV-2 antibodies in healthcare workers at a London NHS Trust. Infect Control Hosp Epidemiol 2021;42:1. https://doi.org/10.1017/ICE.2020.402.

Lumley SF, O'Donnell D, Stoesser NE, Matthews PC, Howarth A, Hatch SB, et al. Antibody Status and Incidence of SARS-CoV-2 Infection in Health Care Workers. N Engl J Med 2021;384:533–40. https://doi.org/10.1056/nejmoa2034545.

Lustig Y, Sapir E, Regev-Yochay G, Cohen C, Fluss R, Olme L, et al. BNT162b2 COVID-19 vaccine and correlates of humoral immune responses and dynamics: a prospective, single-centre, longitudinal cohort study in health-care workers. Lancet Respir Med 2021;9: 999–1009. https://doi.org/10.1016/S2213-2600(21)00220-4

Malagón-Rojas JN, Mercado-Reyes M, Marien Palma R, Lagos L, Rubio V, Delgado G. Seroprevalence of the SARS-CoV-2 antibody in healthcare workers: a multicenter cross-sectional study in ten Colombian cities n.d. https://doi.org/10.1101/2021.07.21.21260103.

Mil
CoV-2 antibodies among healthcare workers at a COVID-19 referral hospital in Milan, Italy. Occup Environ Med 2021;0:oemed-2020-107060. https://doi.org/10.1136/oemed-2020-107060.

Ruiz-Gómez F, Carrasquilla-Barrera A. Modificación del Artículo 7 del decreto 109 de 2021. Bogotá: 2021.

Salata C, Calistri A, Parolin C, Palù G. Coronaviruses: a paradigm of new emerging zoonotic diseases. Pathog Dis 2019;77. https://doi.org/10.1093/FEMSPD/FTAA006.

Sandal A, Yildiz AN. COVID-19 as a Recognized Work-Related Disease: The Current Situation Worldwide. Saf Health Work 2021;12:136–8. https://doi.org/10.1016/j.shaw.2021.01.001.

SEASUN BIOMATERIALS. U-TOP^{TM} COVID-19 Detection Kit . 2021.

Secretaría de Salud Bogotá. Ocupación de Unidades de Cuidado Intensivo Adulto para atención general y COVID-19 en Bogotá. SaluData 2021. https://saludata.saludcapital.gov.co/osb/index.php/datos-de-salud/enfermedades-trasmisibles/ocupacion-ucis/ (accessed January 3, 2022).

SeroTracker. n.d. https://serotracker.com/en/Data (accessed June 23, 2021).

Varela AR, Florez LJH, Tamayo-Cabeza G, Contreras-Arrieta S, Restrepo SR, Laajaj R, et al. Factors Associated With SARS-CoV-2 Infection in Bogotá, Colombia: Results From a Large Epidemiological Surveillance Study. Lancet Reg Heal - Am 2021;2:100048. https://doi.org/10.1016/J.LANA.2021.100048.

Vista de COVID-19 en Colombia: un año después de confirmar su primer caso. n.d. https://revistas.fucsalud.edu.co/index.php/repertorio/article/view/1182/1571 (accessed August 3, 2021).

Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J, et al. Clinical Characteristics of 138 Hospitalized Patients With 2019 Novel Coronavirus-Infected Pneumonia in Wuhan, China JAMA | Original Investigation | CARING FOR THE CRITICALLY ILL PATIENT. JAMA 2020;323:1061–9. https://doi.org/10.1001/jama.2020.1585.

WHO. Timeline of WHO's response to COVID-19 n.d. https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline#event-0 (accessed May 19, 2021).

World Health Organization. Monitoring knowledge, risk perceptions, preventive behaviours and trust to inform pandemic outbreak response. 2020.

World Health Organization (WHO). Colombia Situation n.d. https://covid19.who.int/region/amro/country/co (accessed August 3, 2021).

Prevalence of SARS-CoV-2 infection and SARS-CoV-2-specific antibody detection among health care workers and hospital staff of a university hospital in Colombia.

Figures

Figure 1. Study period in the setting of the COVID-19 pandemic, March – October 2020

<table>
<tr><th>March 6th</th><th>March 11th</th><th>June 25th</th><th>July 21st</th><th>August 12th</th><th>October 30th</th></tr>
<tr><td rowspan="2">First COVID-19 case in Colombia</td><td rowspan="2">The World Health Organization declared a pandemic</td><td colspan="4">Study recruitment period</td></tr>
<tr><td></td><td colspan="2">First wave</td><td></td></tr>
</table>

generating procedures, C. Hospital Ward.

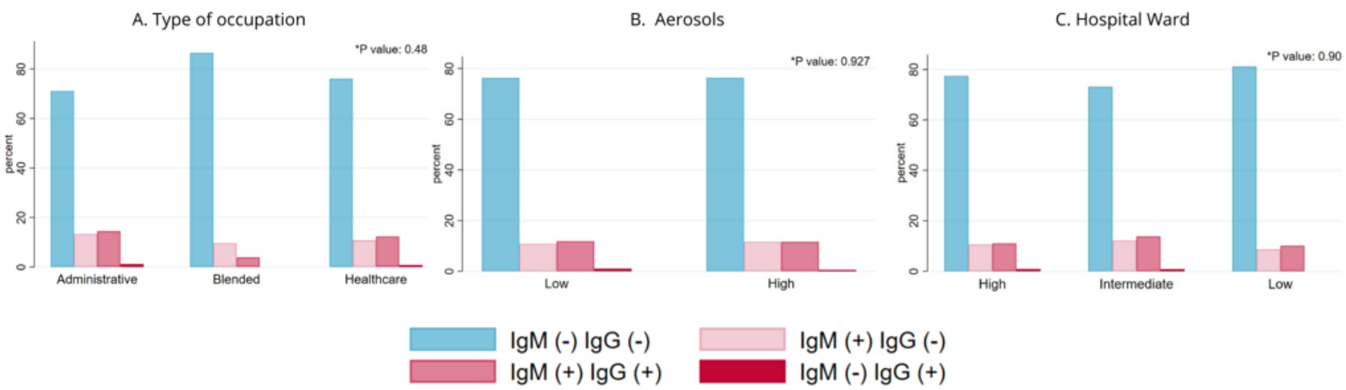

Table 1 Level of exposure of HCWs to SARS-CoV-2 according to the hospital ward, aerosol-generating procedures, and type of occupation.

	High exposure	*Intermediate exposure*	*Low exposure*
Hospital ward	ER, COVID-19 ICU, laboratory, COVID-19 hospitalization	non-COVID-19 hospitalization, surgery, non-COVID-19 ICU, pediatric and neonatal ICU, oncology, specialty wards, external consultation, diagnostic imaging	correspondence, public health, research, and administrative departments
Aerosol generating procedures	Yes		No
Type of occupation	Healthcare and blended		Administrative

Table 2 Socio-demographic and clinical characteristics of participants at enrollment per COVID-19 serostatus.

	Total		*Seropositive*		*Seronegative*		
	n	(%)	n	(%)	n	(%)	p
Total	420		97	23·10	322	76·67	
Gender							
Female	318	75·71	79	81·44	238	73·91	0·130[a]
Male	102	24·29	18	18·56	84	26.·9	
Age in years							
Mean (SD) median (p25-p75)	39·7 (9·75) / 39 (14)		39·8 (10·16) / 39 (13)		39·6 (9·65) / 39 (14)		0·878[b]
Previous COVID - 19	31	7·38	27	87·10	4	12·90	< 0·01[a]

stratum							
Low	63	15·0	18	28·57	45	71·43	
Mid	263	62·77	58	22·05	205	77·95	
High	93	22·20	21	22·58	72	77·42	
Household							
Bogotá	379	90·24	88	90·72	290	90·06	0·848[a]
Outside the city	41	9·76	9	9·28	32	9·94	
Type of occupation							
Administrative	91	21·67	26	26·80	64	19·88	0·113[a]
Blended	52	12·38	7	7·22	45	13·98	
Healthcare	260	61·90	62	63·92	197	61·18	
Missing	17	4·05					
Comorbidities							
Any	124	29·52	32	32·99	92	28·57	0·403[a]
Hypertension	36	8·57	12	12·37	24	7·45	
Obesity (BMI≥30)	46	10.95	12	12·37	34	10·56	
Diabetes	6	1·43	1	1·03	5	1·55	
Asthma	14	3·33	5	5·15	9	2·80	
cancer	9	2·14	4	4·12	5	1·55	
COPD	1	0·24	0	0·00	1	0·31	
Immunosuppression	9	2·14	3	3·09	6	1·86	
Current smoker	19	4·52	3	3·09	16	4·97	
Symptoms at enrollment							0·426[a]
Any	117	27·86	24	24·74	93	28·89	
Cough	22	5·25	8	8·25	14	4·35	
Sore throat	51	12·17	12	12·37	39	12·10	
Fatigue	13	3·10	4	4·12	9	2·80	
Fever	1	0·24	1	1·03	0	0·00	

aPearson's chi-squared test

bDifference Between Means t-test

Table 3. **Factors associated with a positive serology for SARS-CoV-2 in health care workers**

Variable	Bivariate model [a]	Multivariate model [b]	Reduced model [c]						
	PR	p	[95% Cl]	PR	p	[95% Cl]	PR	p	[95% Cl]
Age	1,01	0·584	0·98-1·03	1,01	0·277	0·99-1·04	-	-	-
Previous COVID-19									
No	Ref	-	-	Ref	-	-	Ref	-	-
Yes	4,89	<0·001	3·79-6·31	4,84	<0·001	3·89-5·23	4,82	<0·001	3·87-5·23
Sex									
Male	Ref	-	-	Ref	-	-	-	-	-
Female	1,41	0·130	0·89-2·24	1,40	0· 259	0·79-2·25	-	-	-

Soci stratification									
High	0,75	0·108	0·52-1·07	0,79	0·114	0·44-1·36	-	-	-
Low	Ref			Ref			-	-	-
Type of occupation									
Administrative	Ref	-	-	Ref	-	-	Ref	-	-
Healthcare and blended	0,77	0·188	0 ·52-1·13	0,44	0·088	0·17-1·07	0,45	0·065	0·18 -1·03
Profession									
Professional Nurse	Ref	-	-	Ref	-	-	Ref	-	-
Nursing assistant	1,90	0·023	1·10-2·81	2,21	0·032	1·10-3·52	2,39	0·01	1·27-3·65
Medical doctors and students	1,30	0·339	0·74-2·05	2,18	0·039	1·07-3·52	1,70	0·109	0·89-2·80
Laboratory workers	1,58	0·126	0·86-2·50	2,21	0·049	1·02-3·62	2,02	0·056	0·98-3·34
Respiratory therapist and physiotherapist	0,67	0·464	0·23-1·60	0,50	0·321	0·13-1·63	0,56	0·404	0·15-1·72
Other Non-healthcare professionals	1,43	0·154	0·87-2·14	1,58	0·259	0·70-2·89	1,26	0·535	0·58-2·37
Hospital ward									
Low exposure ward	0,74	0·432	0·79 -1·69	0,85	0·734	0·36-1·76	-	-	-
Intermediate exposure ward	1,90	0·386	0·79-1·69	1,35	0·283	0·78-2·14	-	-	-
High exposure ward	Ref			Ref			-	-	-
Number of wards									
One ward	Ref	-	-	Ref	-	-	-	-	-
More than 1 ward	0,82	0·445	0·50-1·37	0,80	0·565	0·38-1·55	-	-	-
Aerosol exposure									
High	1,00	0·993	0·70-1·42	1,63	0·114	0·91-2·60	-	-	-
Low				Ref			-	-	-
Hand washing duration									
>20 s	Ref	-	-	Ref	-	-	-	-	-
0-20s	1,04	0·832	0·71-1·53	1,29	0·332	0·78-2·00	-	-	-
Hand washing frequency									
0-4 times/day	Ref	-	-	Ref	-	-	-	-	-
5-10 times/day	0,91	0·735	0·45-1·65	1,24	0·653	0·53-2·43	-	-	-
>10 times/day	0,78	0·409	0·39-1·42	1,03	0·991	0·42-2·14	-	-	-
Number of									

coh									
0-1	Ref	-	-	Ref	-	-	-	-	-
2-mar	1,17	0·448	0·78-1·67	1,11	0·700	0·66-1·74	-	-	-
4 or more	1,66	0·036	1·03-2·38	1,28	0·474	0·63-2·27	-	-	-

[a]Log-Likelihood intercept only: -215.579

[b]Akaike Information Criterion: 385,851; Bayesian Information Criterion: 465,33; Log Likelihood of the model: -172.93

[c]Akaike Information Criterion: 374,436; Bayesian Information Criterion: 414,23; Log-Likelihood of the model: -177.22